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14. ABSTRACT This TOP enhances test methods and techniques outlined in TOP 04-2-016, Ammunition, Small Arms (09 February 2009) for evaluating the performance characteristics of small arms ammunition in natural cold weather conditions.					
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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 04-4-004A
DTIC AD No.

30 May 2012

NATURAL COLD WEATHER ENVIRONMENT TEST OF AMMUNITION,
SMALLS ARMS

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*This TOP supersedes TOP 04-4-004, Arctic Environmental Test of Small Arms Ammunition, 24 November 1969.

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1. SCOPE.

The procedures in this Test Operations Procedure (TOP) are to supplement and enhance the procedures outlined in TOP 04-2-016^{1*}, and will be used collectively. Testing in a natural cold weather environment is used to substantiate or supplement data obtained from simulated tests conducted during the early design phases of testing. Testing in the cold weather environment generally is not performed until data from simulated environment tests provide reasonable assurance that the test item will function satisfactorily when subjected to the conditions that would be encountered in the natural cold environment. Not all tests performed on small arms ammunition need be repeated in the cold. The subtests listed below are the minimum that should be considered when planning a cold environment test.

a. Initial Inspection. This test provides for an inspection of the test item to identify damage received during shipping and handling and to determine its physical characteristics.

b. Human Factors Engineering (HFE) and Safety. The objective of this subtest is to document if all accessories and components of the test ammunition enable operation by test personnel wearing the appropriate cold environment winter uniform Extended Cold Weather Clothing System (ECWCS).

c. Firing Tests. The objectives of these subtests are to assess the cold weather operational performance of the ammunition.

(1) Accuracy and Dispersion. The objective of this subtest is to document the accuracy and dispersion of small arms ammunition under natural cold environmental conditions.

(2) Velocity. The objective of this subtest is to assess velocity of small arms ammunition at the muzzle of the weapon under natural cold environmental conditions.

(3) Tracer Evaluation. The objective of this subtest is to assess if the test cartridge tracer element enables designating targets and adjusting fire on targets in a natural cold environment.

(4) Signature and Safety Effects. The objective of this subtest is to document and measure the position disclosing effect created by the cumulative smoke, muzzle flash, ice fog, and sound of the test ammunition when fired under natural cold environmental conditions.

d. Manpack Mobility. The objective of this subtest is to document the ease of carrying and transporting the test ammunition cross-country, utilizing over snow mobility techniques, such as wearing snowshoes and skis.

*Superscript numbers correspond to Appendix B, References.

2. FACILITIES AND INSTRUMENTATION.

- a. Table 1 presents facilities requirements.

TABLE 1. FACILITIES REQUIREMENTS

ITEM	REQUIREMENT
Firing ranges	Ranges suitable to ensure safe firing at all required distances. Range fans and surface danger zones must allow for the effect of catastrophic failure of weapons or ammunition.
Test stands	Must safely restrain the weapon platform during firing.
Ground mounts (bipods, tripods, and gimbals)	Specific to weapons.
Support ammunitions	Used to verify test setup.
Reference ammunition	Assessed for chamber pressure and velocity measurements.
Targets	Either physical or electronic, providing the capability of recording the X and Y coordinates of each projectile passing through the plane of the target. Specific accuracy and precision requirements will vary by ammunition type and the particular test performed.
Pressure barrels	Barrels chambered for the specific test ammunition and ported for electronic or crusher type pressure gauges.

- b. Table 2 presents instrumentation requirements.

TABLE 2. INSTRUMENTATION REQUIREMENTS

ITEM	MAXIMUM PERMISSIBLE ERROR OF MEASUREMENT*
Velocimeter	0.1 % or 5 m/s (whichever is highest) for bursts to 6000 rpm.
Thermograph/thermocouples	± 0.6 °C (1 °F)
Cyclic rate recorder	± 1 % at rates up to 6000 rpm and burst lengths of 100 rounds.
Star gauge and borescope	± 0.025 mm
<p>*Values can be assumed to represent ± 2 standard deviations; thus, the stated tolerances should not be exceeded in more than 1 measurement of 20.</p> <p>LEGEND:</p> <p>% percent</p> <p>C Celsius</p> <p>F Fahrenheit</p> <p>mm millimeter</p> <p>m/s meters per second</p> <p>rpm rounds per minute</p>	

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- c. Table 3 presents other required support.

TABLE 3. OTHER REQUIRED SUPPORT

ITEM	REQUIREMENT
Photographic	Photo or video documentation may be required to capture any anomalies found during testing.
Meteorological	Periodic recordings of conditions at firing point and target area as specified in the test plan. At a minimum, temperature, relative humidity, wind speed, wind gusts, and wind direction.
Appropriate cold weather Clothing	When assessing HFE the appropriate military uniform must be utilized to ensure all issues are determined. The ECWCS is the standard uniform.
Skis and snowshoes	As applicable

3. REQUIRED TEST CONDITIONS.

3.1 Planning.

a. Since natural cold environmental tests are normally scheduled from October through March (6 months), ensure the test items (test and comparison ammunition) and weapons for each ammunition type to be fired are delivered to the test center prior to 01 October. Ammunition shipments (barges) are normally scheduled for the spring and fall. Contact the ammunition officer for the exact schedule.

b. Temporary duty (TDY) personnel may be required to augment assigned personnel and must be trained to the degree that they are as proficient on the individual weapons as the Soldiers who will use the weapon. If Soldiers are desired, ensure a Test Schedule and Review Committee (TSARC) request is submitted as early as possible.

c. Ensure that all test personnel are familiar with the required technical and operational characteristics of the item under test in a cold environment test and record these criteria in the test plan.

d. Review all instructional material issued with the test item by the manufacturer, contractor, or government, as well as reports of previous tests conducted on the same type of equipment. Familiarize all test personnel with these documents and have them available for reference.

e. Review the test item's capability documents, such as the Initial Capabilities Document (ICD), Capabilities Development Document (CDD), or Capabilities Production Document (CPD) for applicable cold weather requirements. For evaluated programs, the US Army Test and Evaluation Command (ATEC) coordinated and approved System Evaluation Plan (SEP) is the governing document. The SEP will document the methodology and data requirements and any unique test and evaluation methodologies beyond those stipulated in this TOP. For non-

acquisition projects, the customers test requirements will be followed to the extent possible, based on information in the Request for Test Services (RFTS) and direct communication with the customer, in accordance with ATEC Pamphlet (Pam) 73-1².

f. Review the Safety Assessment Report (SAR) and all instructional material issued with the test item by the developer and manufacturer, as well as reports of previous tests conducted on the same model or closely related item for applicable cold weather related issues. Review the safety release if available.

g. Prepare adequate safety precautions to provide safety for personnel and equipment and ensure all applicable safety regulations and policies are followed throughout the test. If required, ensure that a safety release and Human Research Protection Plan (HRPP) have been obtained prior to test conduct.

h. Ensure all test personnel have appropriate winter clothing and individual field equipment, as required.

i. Ensure that when not in use, all test and comparison ammunition are stored and maintained in an unsheltered area, exposed to ambient air temperature, and prevailing weather conditions. Ensure proper security procedures are maintained throughout storage. A portable cold chamber may be utilized to maintain stable test conditions.

3.2 Test Sequence.

When testing in a cold environment, schedule the safety and nondestructive tests first. This TOP does not include a recommended sequence for the complete series of subtests due to the many variations of ammunition and weapon designs. Test officers should consider scheduling of ranges, facilities, weather, and personnel when establishing a test schedule.

3.3 Test Conduct.

a. Support Weapons. The safety and suitability of small arms ammunition is interrelated with the weapons with which it is used. Care must be taken during testing to assure that the distinction is made between inherent ammunition functioning and weapon induced problems. Weapons will be maintained in accordance with technical manuals, if available. Weapons will always be cleaned, inspected, and lubricated (CIL) at the end of each test procedure and before the start of another procedure (the CIL at the end of a test procedure may serve as the CIL for the start of a subsequent test procedure based on the judgment of the test officer). At a minimum, the CIL will be conducted at the operator level (often referred to as "field strip and clean"). More detailed maintenance will be performed as required. Weapon lubricants, gas port settings, etc., may be specific to test conditions such as extreme temperatures and must be applied in accordance with technical manuals or requirements documents. All maintenance actions will be recorded. Weapon maintenance procedures will be coordinated with the test customer.

b. Firing Tests. Test ammunition must be fired to determine its performance. The procedures in this TOP are a supplement to TOP 04-2-016 and should be used with in

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conjunction with TOP 03-2-045³ and TOP 03-4-004⁴. Testing in a cold environment uses standard small arms ammunition procedures, with only slight modifications or minor procedural changes due to the unique challenges when testing in subzero temperatures.

c. Support (comparison) Ammunition. A limited amount of test ammunition should be preserved for actual testing. Support ammunition similar to the test ammunition should be provided, if possible. The support ammunition is used to confirm test set ups, instrumentation function, support weapons function, and to perform trial runs prior to the use of the test ammunition. Some support ammunition may be used for direct comparison with the test ammunition in comparative tests such as velocity, muzzle flash, tracer intensity, etc. The support ammunition used must be fully identified; record the full nomenclature, Department of Defense Identification Code (DODIC), condition code (CC), and lot number.

d. Ammunition Handling. The test ammunition will be kept in its original shipping and storage containers until immediately before use. Make a general visual examination of the ammunition after it is removed from its packaging; record any discrepancies such as shipping damage, evidence of improper storage, etc. Save some of the original shipping containers and packing materials; they are often needed to repack ammunition.

4. TEST PROCEDURES.

4.1 Initial Inspection.

There are no significant modifications required to conduct the Initial Inspection in a cold environment. Special attention should be paid to damages that appear to be caused by cold weather or mishandling in the cold.

4.2 Human Factors Engineering (HFE) and Safety.

a. HFE and Safety will be observed throughout all phases of testing, concentrating on issues caused by cold weather clothing or adverse weather conditions.

b. All personnel will pay special attention to factors that impede with the use of the ammunition, such as clothing interference, inadvertent mishandling caused by bulky gloves or mittens, etc. Areas of concern may include difficulty opening containers, loading, unloading, clearing misfires, or storing ammunition.

4.3 Firing Tests.

These procedures and those outlined in TOP 04-2-016 will be used to establish range set up and test conduct for all firing events. Additional guidance is given for the various specialized events.

a. Cold conditioning should occur outdoors for a period of at least 24 hours prior to commencement of each test event for all test and comparison ammunition. However, should unusual conditions persist; portable environmental chambers may be used to supplement natural

environmental conditioning. Each phase of the subtest will be conducted in ambient air temperatures of -18 °C to -31 °C (0 °F to -25 °F), -32 °C to -46 °C (-26 °F to -50 °F), or as specified in the requirements documents.

b. When establishing ranges, the test officer should consider firing line orientation due to low-level sun on the southern horizon when in a northern latitude (above 60 degrees north latitude).

c. All test participants will wear anti-contact gloves and balaclavas when handling weapons and ammunition to reduce the chance of contact frostbite from contact with extremely cold metals.

d. All weapons will be lubricated for cold weather use in accordance with appropriate Technical Manuals (TMs). The use of the wrong lubricants can severely affect performance of the weapons and may cause undue malfunctions, weapons breakage, and test delays.

e. To reduce the chance of weapons breakage or malfunction during initial firing, begin firing at a slow rate of fire to allow the weapon to warm up before attempting maximum rate of fire.

f. If using optics, such as rifle scopes and close combat optics, care must be taken not to breathe or exhale onto the lenses of the optics. Moisture will form on the lenses, making target viewing impossible.

g. Weapons to be used in these tests will be inspected, verified serviceable, and documented by a certified maintainer (Installation Maintenance Facility).

h. Zero weapons using support ammunition to ensure proper functioning prior to test events. This should be conducted in temperatures comparable to the test temperature. Fire verification rounds using test ammunition just prior to test firing.

4.3.1 Accuracy and Dispersion.

This subtest determines the inherent accuracy and dispersion characteristics of the test ammunition when fired in a natural cold environment. Accuracy is a measure of the ability of weapon and ammunition combination to center projectile impacts on the point of aim. Dispersion is the extent to which projectile impacts spread about the center of impact because of shot-to-shot variations. Methods of calculating measurements of accuracy and dispersion are given in International Test Operations Procedure (ITOP) 04-2-829⁵.

a. Meteorological data are an absolute requirement for exterior ballistics computations. Meteorological conditions can affect the performance of ammunition. Temperature, wind, air density, and humidity all influence the ballistics of the ammunition to varying degrees. Testers must understand the limitations of all ammunition being tested and make certain test conditions are not outside the listed limitations of the test item. The results from cold weather should be

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compared to those from temperate climates to determine the effect of temperature on the inherent accuracy or dispersion.

b. During accuracy firing, weapons should be fired from rigid test mounts (Mann type barrels) to eliminate human error. Manned firing should be performed as a last resort. If manned firing is performed, ensure personnel are fully qualified on the weapons to be fired and the weapon is used with a solid benchrest. When firing for extended periods, the cold can greatly affect the manned firer and care must be taken to ensure frequent warming is allowed. During warming breaks, the weapons and ammunition will remain outside.

c. All ammunition (test and support) will be conditioned and maintained to the temperatures listed in the test plan until the rounds are fired.

d. Rates of fire will be slow and deliberate unless otherwise dictated by the customer or test plan; this will allow the weapon to remain cooler and to minimize heat transfer to the ammunition.

4.3.2 Velocity Firings.

The purpose of this test is to gather data that will allow the comparison of the muzzle velocity for specific ammunition/weapon combinations in multiple environments. The computations are used to construct firing tables, produce computer programs for weapon sights, establish firing range safety dimensions, etc. Final data analysis and publication of firing tables is the responsibility of the Firing Tables and Ballistics Division of the U.S. Army Armament Research, Development, and Engineering Center. Details of the test procedure and data requirements must be coordinated with this group prior to testing.

a. The test method for this firing is detailed in ITOP 03-2-601⁶. The information presented below is intended to supplement the ITOP and to provide procedures specifically for small arms ammunition.

b. Rates of fire will be slow and deliberate. This will allow the weapon to remain cooler, so not to transfer heat to the ammunition as quickly between rounds.

4.3.3 Tracer Evaluation.

A traced projectile is provided with an element (usually pyrotechnic) to enable the visual tracking of the trajectory of the projectile. Tracer ammunition is used by the shooter to adjust fire onto a target or to indicate a target for other shooters. Tracers may be designed to emit a constant brightness, or they may be designed to be dim near the weapon muzzle (so as to not disclose the shooters position or interfere with night vision devices), and increase in brightness after a specific distance.

a. When firing in temperatures below 29 °C (-20 °F), tracer observation may be obscured by the occurrence of ice fog from the muzzle blast. Ice fog is a phenomenon in temperatures below 29 °C (-20 °F) when a heat source (the weapon firing) causes moisture in the air to liquefy

and immediately refreeze on particulates (possibly from the smoke of firing) the in the air, forming fog. It may take several seconds to minutes for this to dissipate.

b. Positioning cameras ahead of and/or slightly to the left or right of the weapon may be required to alleviate the visibility problem. The use of human observers may also be required.

4.3.4 Signature and Safety Effects.

Signature effects are those that characterize the use of a specific ammunition incidental to its intended performance. Some signature effects, such as smoke, ice fog, and muzzle flash, can reveal a shooter's position and interfere with his view of the target. Other effects, such as noise and recoil, have safety implications. In all cases, signature effects affect the utility and usefulness of ammunition.

a. Firing weapons in temperatures below 29 °C (-20 °F) can cause the formation of ice fog, which can disclose the location of the weapon or obscure the shooter's observation of the target.

b. Flash tests are usually done as comparison-type tests in a dark environment, however in the arctic and subarctic during periods of cold below 29 °C (-20 °F), it would be desirable to conduct this test during periods of daylight to view and document other visual effects such as ice fog. Test ammunition will be fired in alternate trials with standard (support or comparison) ammunition to determine if the test ammunition provides an increase or decrease in flash as compared to the standard ammunition.

4.3.5 Manpack Mobility.

a. Small arms ammunition is required to be carried by the individual Soldier. This subtest determines the cold weather effects of transporting ammunition by the Soldier. For example, when moving through snow covered terrain, snow intrusion into ammunition pouches and other carrying equipment is common. Repeated transition from unheated to heated areas causes condensation and freezing.

b. This test will be conducted in temperatures from 0 °F (-18 °C) to the lowest available.

c. Perform the following procedures:

(1) Inspect all test and comparison ammunition for damage and document all discrepancies.

(2) Pack the test and comparison ammunition in the prescribed carrying cases and transport the items over the following courses:

(a) Snowshoe three miles through dense, snow-covered brush. Conduct an operational/functional check: insert magazine, load and unload rounds, and document results. Thoroughly inspect each test item and document all discrepancies.

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(b) Snowshoe five miles over open-covered (cross-country) terrain. Conduct an operational/functional check: insert magazine, load and unload rounds, and document results. Thoroughly inspect each test item and document all discrepancies.

(c) Ski 10 miles over cross-country trails (as required by CPD). Conduct an operational/functional check: insert magazine, load and unload rounds, and document results. Thoroughly inspect each test item and document all discrepancies.

(d) Conduct individual movement techniques for 100 meters, over snow-covered terrain. Conduct an operational/functional check: insert magazine, load and unload rounds, and document results. Thoroughly inspect each test item and document all discrepancies.

(e) Conduct operations in a Military Operations in Urban Terrain (MOUT) environment, concentrating on transitions between heated and unheated buildings. Personnel will remain in each environment for a minimum of 10 minutes, for at least 3 iterations. Conduct an operational/functional check: insert magazine, load and unload rounds, and document results. Thoroughly inspect each test item and document all discrepancies.

d. Data Required.

- (1) Damage attributed to environmental effects.
- (2) Problems encountered while transporting ammunition.
- (3) Damage to ammunition due to handling.
- (4) Meteorological conditions at the test site.
- (5) Maximum load that can be carried in each mode of movement.
- (6) Photographs of stowed ammunition and packaging and problems encountered.
- (7) Results of the operational/functional check.

5. DATA REQUIRED.

a. Specific data requirements are included in TOP 04-2-016 for each specific subtest. For evaluated programs, the SEP must be reviewed to assure that the required data will be obtained. For non-acquisition projects, review the RFTS to determine data requirements.

b. Data should be presented using standard terminology and definitions. A comprehensive guide is presented in Allied Ordnance Publication (AOP) 38 Edition 5⁷. Standard definitions for weapon/ammunition interactions and malfunctions may be found in TOP 03-2-045.

c. The Test Center will provide Safety Release or Safety Confirmation recommendations

to the proper US Army Evaluation Center (AEC) Test Division based on any safety test anomalies occurring during the natural cold environmental tests.

6. DATA PRESENTATION.

a. Due to the multiplicity of subtests, this TOP does not include specific data forms or formats (see TOP 04-2-016 for data format samples). In all cases, the test data must be presented in formats that are factual, comprehensive, and easy to understand. General guidance on presentation of data in reports is given in ATEC Publication Number 1-8⁸. Use this guidance for both printed and electronic presentations.

b. Level 1 through 3 data are not usually published, but are retained for future use or analysis (see ATEC Pamphlet 73-1, Chapter 4). Data levels 4 and 5 form the basis for test reports, safety release recommendations, etc.

c. Test results are analyzed by suitable statistical procedures for comparing samples, for obtaining point or interval estimates of a parameter, and for determining from test results whether specific requirements have been satisfied. ITOP 03-1-005⁹ provides guidance on analyzing and presenting test results.

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APPENDIX A. ABBREVIATIONS.

AOP	Allied Ordnance Publication
ATEC	US Army Test and Evaluation Command
C	Celsius
CC	condition code
CDD	Capabilities Development Document
CIL	cleaned, inspected, and lubricated
CPD	Capabilities Production Document
DODIC	Department of Defense Identification Code
ECWCS	Extended Cold Weather Clothing System
F	Fahrenheit
HFE	Human Factors Engineering
HRPP	Human Research Protection Plan
ICD	Initial Capabilities Document
ITOP	International Test Operations Procedure
m/s	meters per second
mm	millimeter
MOUT	Military Operations in Urban Terrain
Pam	Pamphlet
RFTS	Request For Test Services
rpm	rounds per minute
SAR	Safety Assessment Report
SEP	System Evaluation Plan
TDY	Temporary Duty
TM	Technical Manual
TOP	Test Operations Procedure
TSARC	Test Schedule and Review Committee

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APPENDIX B. REFERENCES.

1. TOP 04-2-016, Ammunition Small Arms, 09 February 2009.
2. ATEC Pam 73-1, System Test and Evaluation Procedures, 16 June 2010.
3. TOP 03-2-045, Small Arms - Hand and Shoulder Weapons, and Machineguns, 17 September 2007.
4. TOP 03-4-004, Arctic Environmental Test of Individual Weapons, Rifles (Semi-Automatic and Automatic), and Pistols, 29 May 1969.
5. ITOP 04-2-829, Vertical Target Accuracy and Dispersion, 07 September 1999.
6. ITOP 03-2-601, Firing Tables and Ballistic Match Tests, 16 October 1995.
7. AOP 38 Edition 5, Glossary of Terms and Definitions Concerning the Safety and Suitability of Service Munitions, Explosives, and Related Products, June 2009.
8. ATEC Publication Number 1-8 (change 2), Technical Document Style Manual, April 2007.
9. ITOP 03-1-005, Statistics for Test Assessment, 23 October 2003.

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APPENDIX C. APPROVAL AUTHORITY.

CSTE-TM

18 June 2012

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, US Army Evaluation Center
US Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 04-4-004A, Natural Cold Weather Environment
Test of Ammunition, Small Arms, Approved for Publication

1. TOP 04-4-004A, Natural Cold Weather Environment Test of Ammunition, Small Arms, has been reviewed by the US Army Test and Evaluation Command (ATEC) Test Centers, the US Army Operational Test Command, and the US Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. An abstract of the document is as follows:

The procedures in this TOP are to supplement and enhance the procedures outlined in TOP 04-2-016, and will be used collectively. Testing in a natural cold weather environment is used to substantiate or supplement data obtained from simulated tests conducted during the early design phases of testing. Testing in the cold weather environment generally is not performed until data from simulated environment tests provide reasonable assurance that the test item will function satisfactorily when subjected to the conditions that would be encountered in the natural cold environment. Not all tests performed on small arms ammunition need be repeated in the cold.

2. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at <https://vdl.s.atc.army.mil/>.

3. Comments, suggestions, or questions on this document should be addressed to US Army Test and Evaluation Command, 2202 Aberdeen Boulevard, ATTN: CSTE-TM, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), US Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, MD 21005–5001. Technical information may be obtained from the preparing activity: Test Management Office (TEDT-YPC-TM), US Army Cold Regions Test Center, PO Box 31350, Fort Greely, AK 99731. Additional copies can be requested through the following website: <http://itops.dtc.army.mil/RequestForDocuments.aspx>, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060–6218. This document is identified by the accession number (AD No.) printed on the first page.